Symposium on Cloud Computing (SoCC)

Kairos: Preemptive Data Center Scheduling Without Runtime Estimates

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October 11, 2018

Kairos

Data center scheduling without task runtime estimates

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Kairos key idea

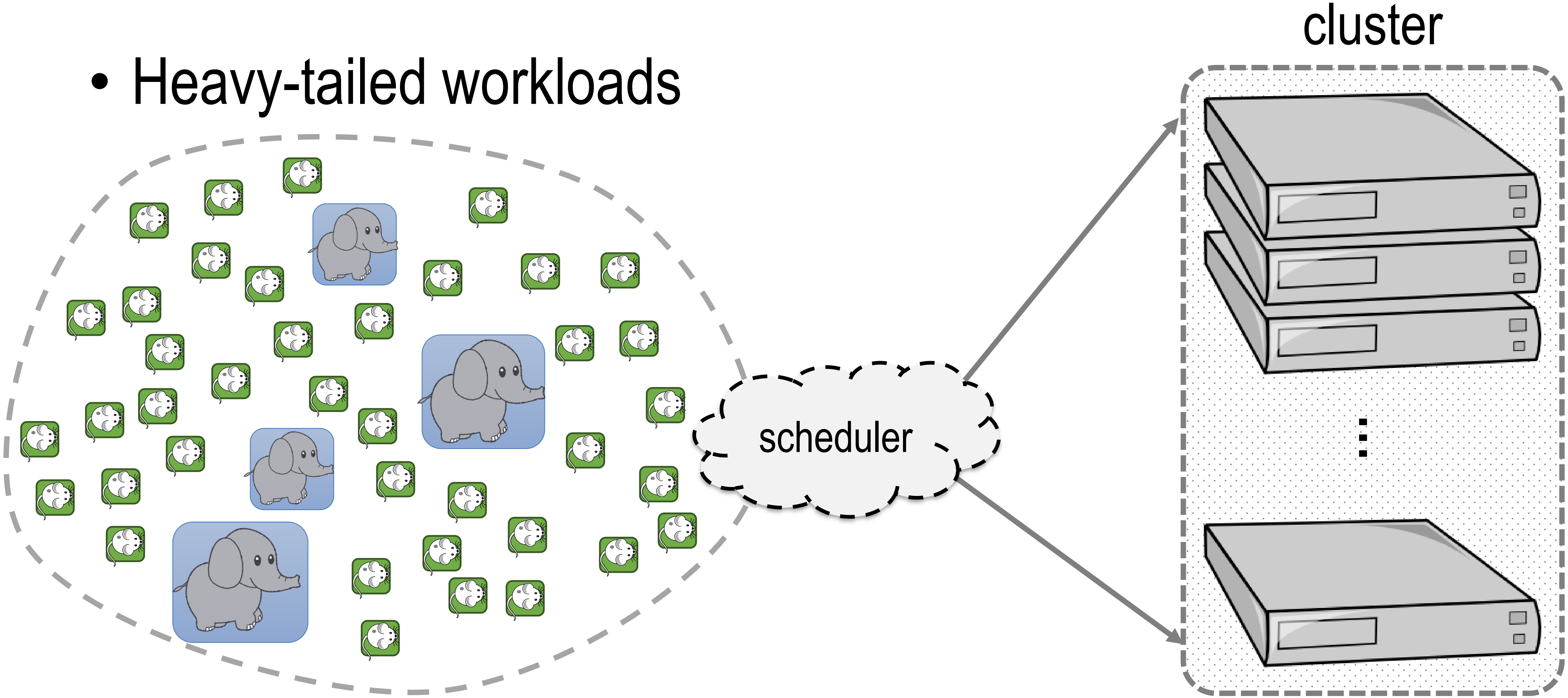
- New preemption approach

✓ No head-of-line blocking

✓ Good scheduling performance

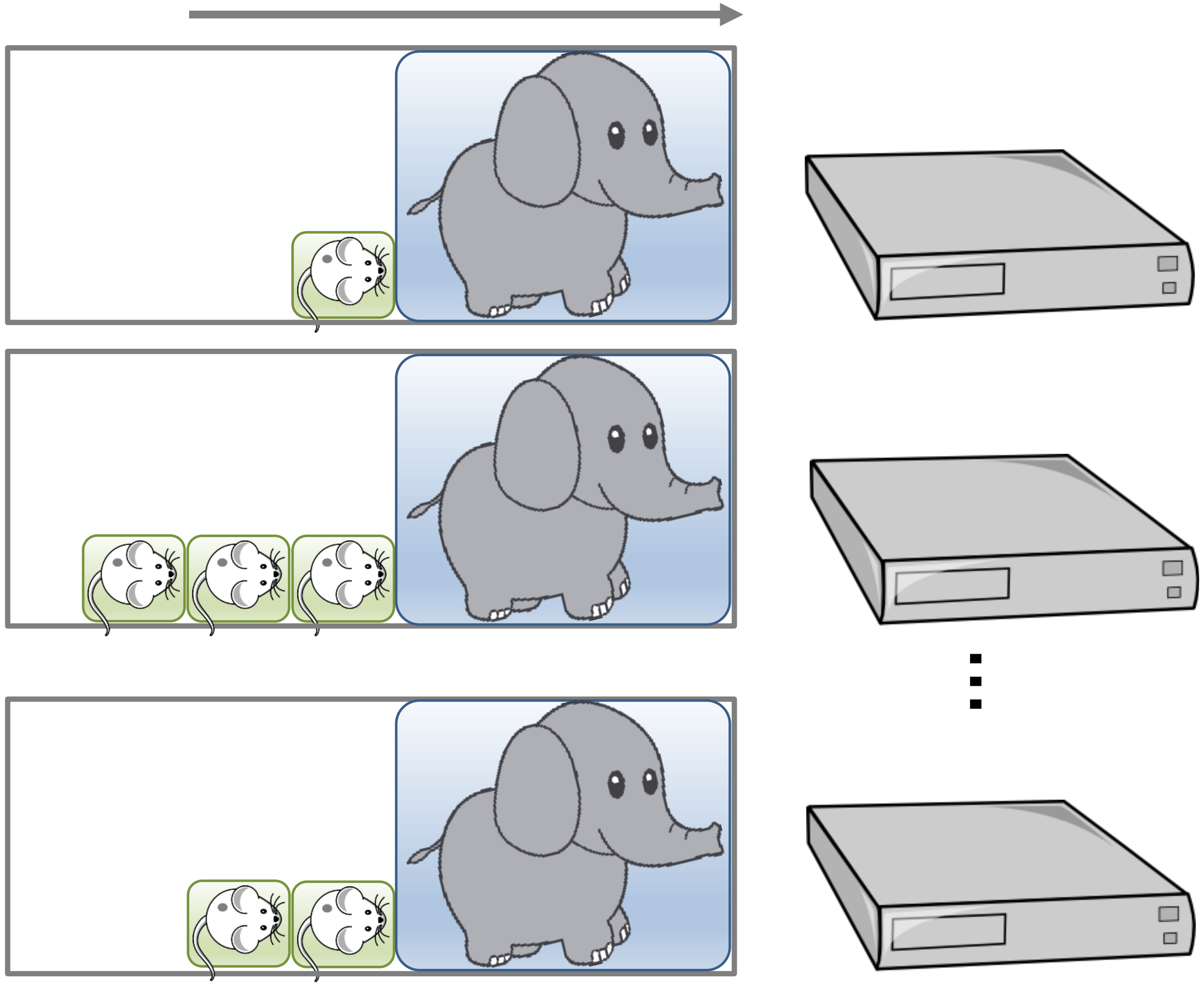
Data center scheduling challenge

- Heavy-tailed workloads

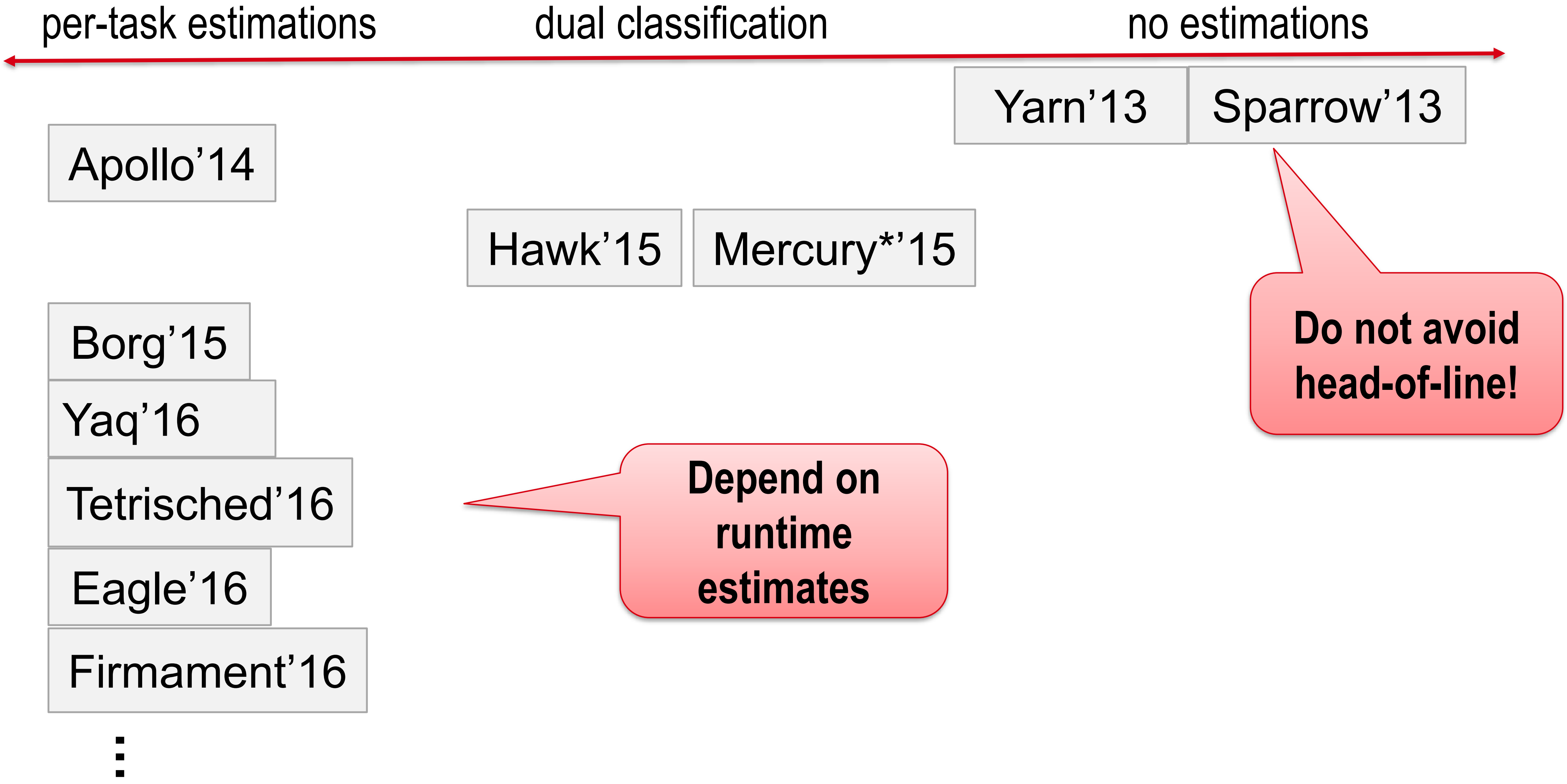


Problem: head-of-line blocking

- Short waiting for long
- High likelihood



Historical use of runtime estimates



per-task estimations

dual classification

no estimations

Yarn’13

Sparrow’13

Apollo’14

Hawk’15

Mercury*’15

Borg’15

Yaq’16

Tetrisched’16

Eagle’16

Firmament’16

⋮

Do not avoid head-of-line!

Depend on runtime estimates

Hard to obtain reliable estimates

- Mis-estimations happen
  - unseen jobs, skewed input, failures/spikes

- Consequences:
  - poor scheduling decisions*, violate SLOs^
  - complex designs to compensate

**Job-aware scheduling in Eagle: Divide and Stick to Your Probes (SoCC'16)*

^ Tetrisched: global rescheduling with adaptive plan-ahead in dynamic heterogeneous clusters (Eurosys'16)

Can we dispense with task runtime estimates altogether?

Can we dispense with task runtime estimates altogether?

- ✓ Avoid head-of-line blocking
- ✓ No task runtime estimates

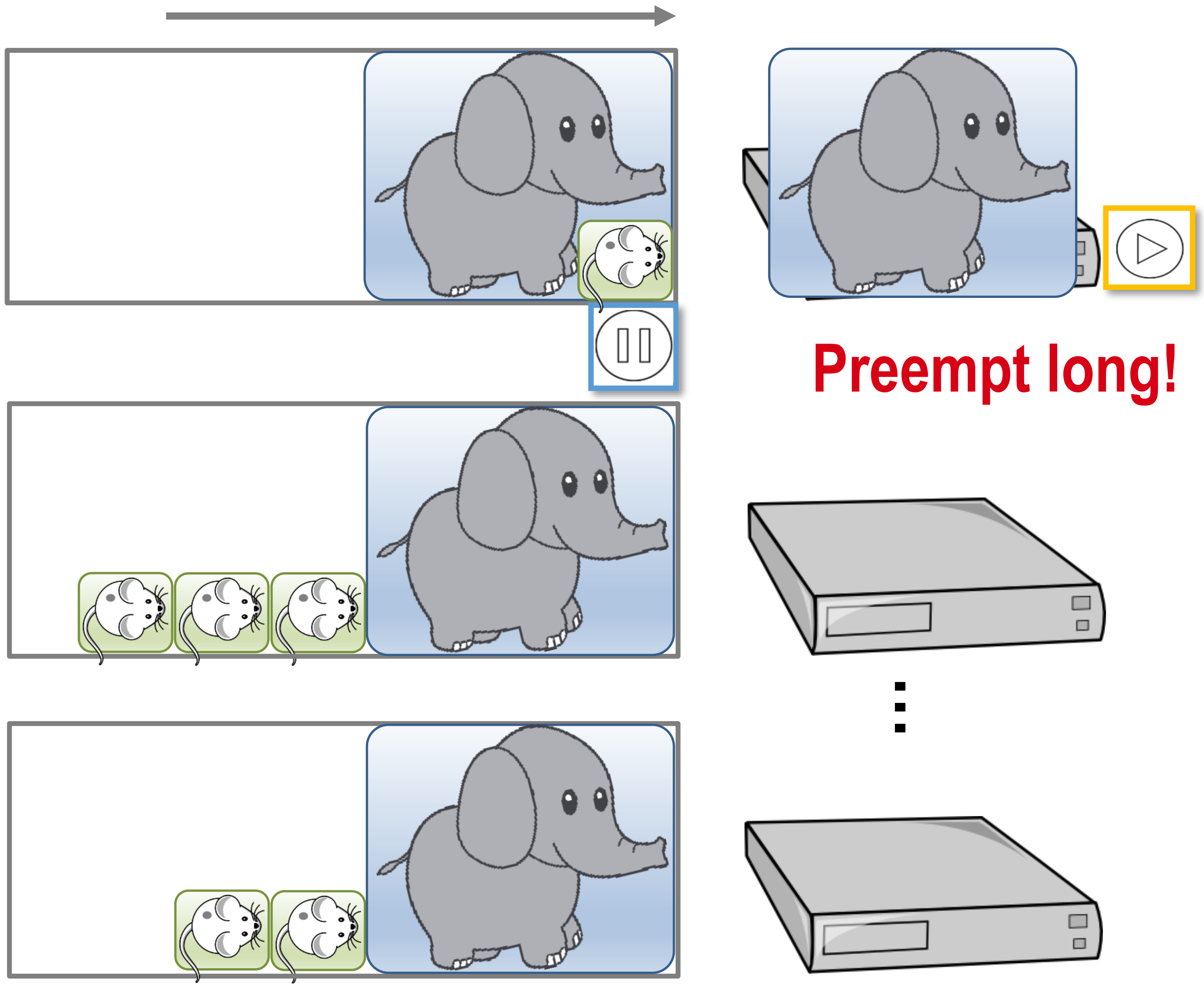
Kairos

Kairos insight

Preemption in Kairos

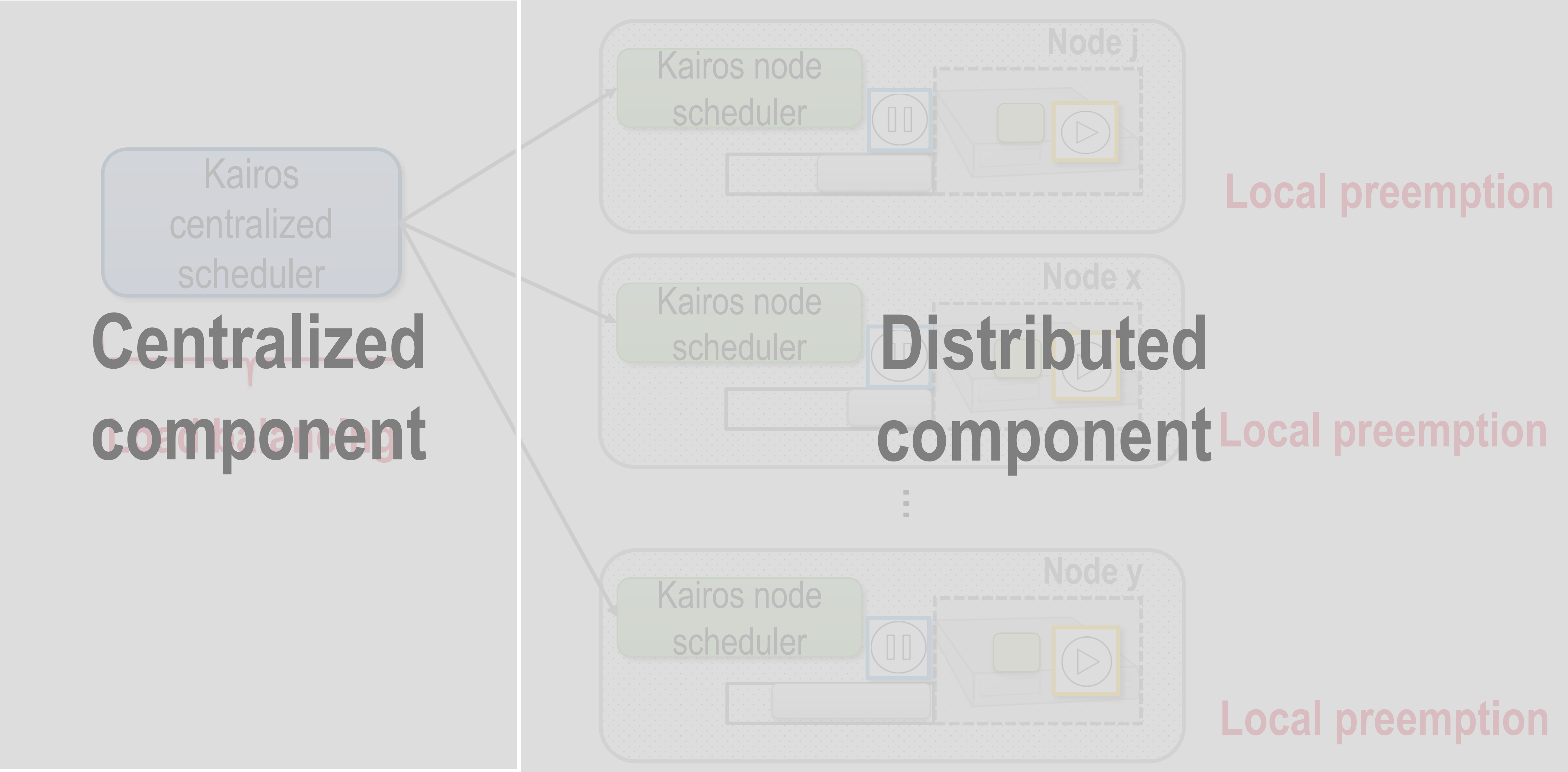
Costly resuming elsewhere:

Do preemption locally!



Preempt long!

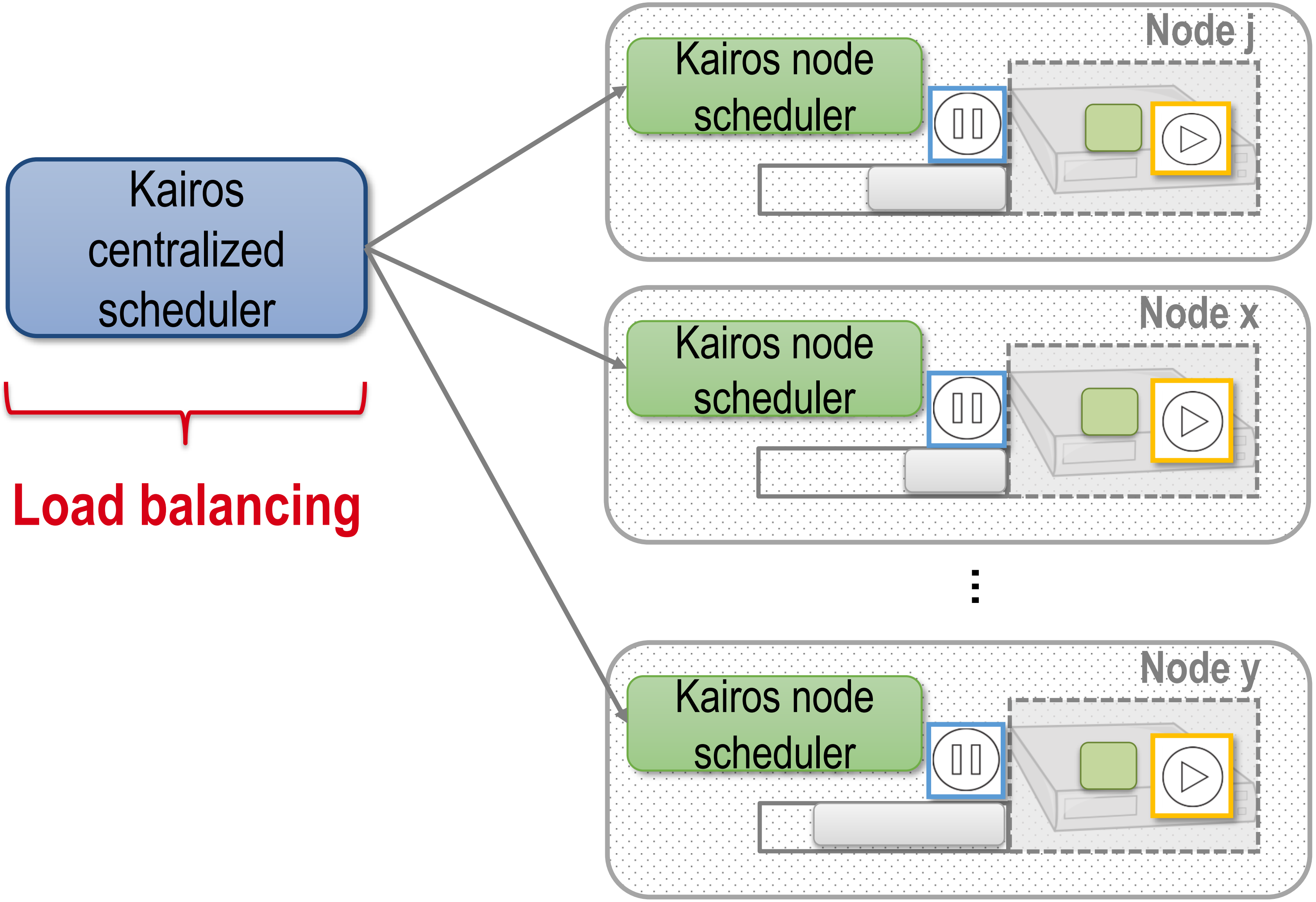
Kairos architecture



Centralized component

Distributed component

Kairos architecture



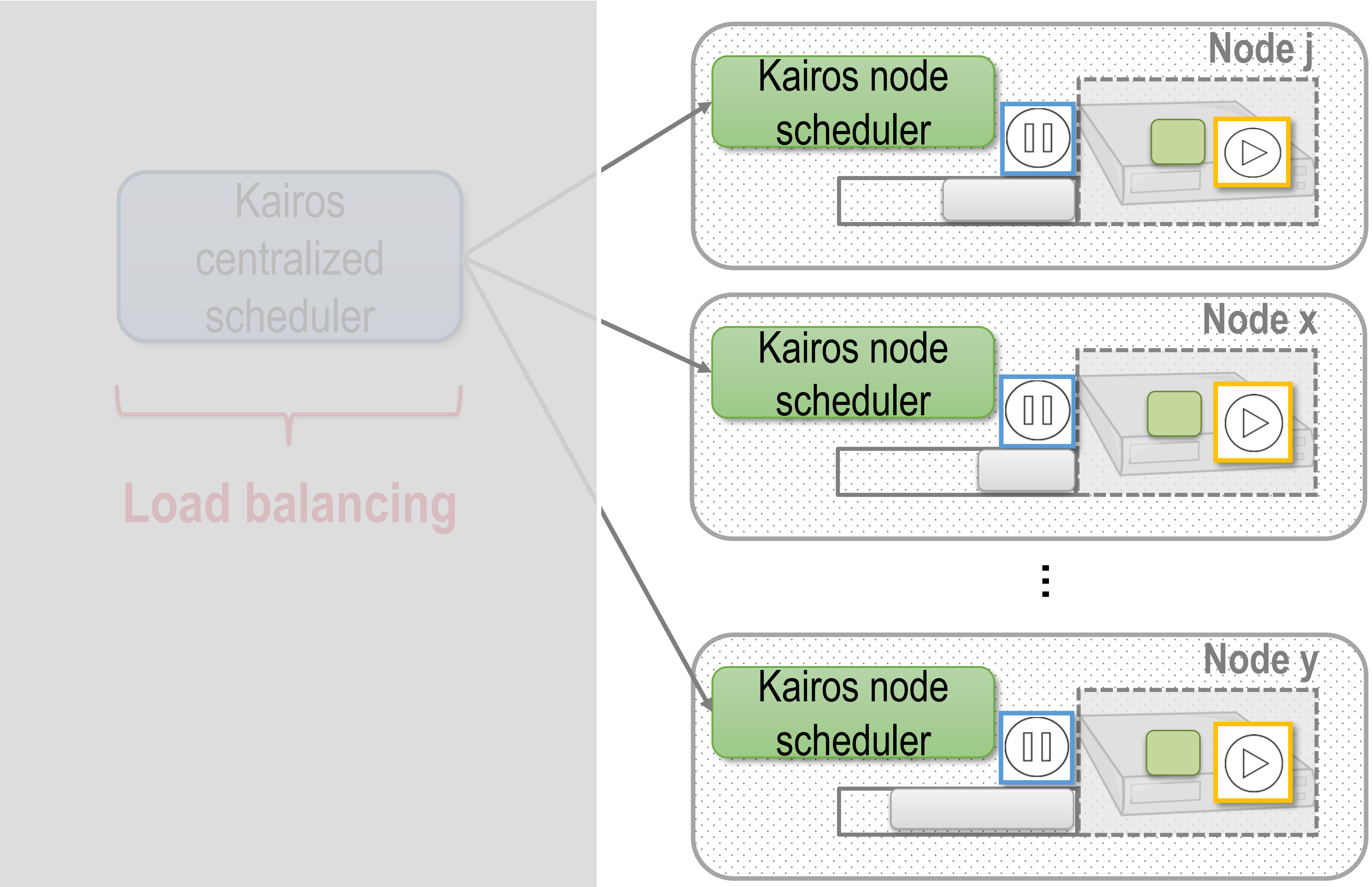
Load balancing

Local preemption

Local preemption

Local preemption

Kairos architecture



Local preemption

Local preemption

Local preemption

Least-Attained Service (LAS)

- Preemptive policy
- Give resources to task that received least service

✓New task runs immediately

✓Runs as long as it is the one with least received service

LAS rationale

- Good for heavy-tailed workloads*

- Benefits:

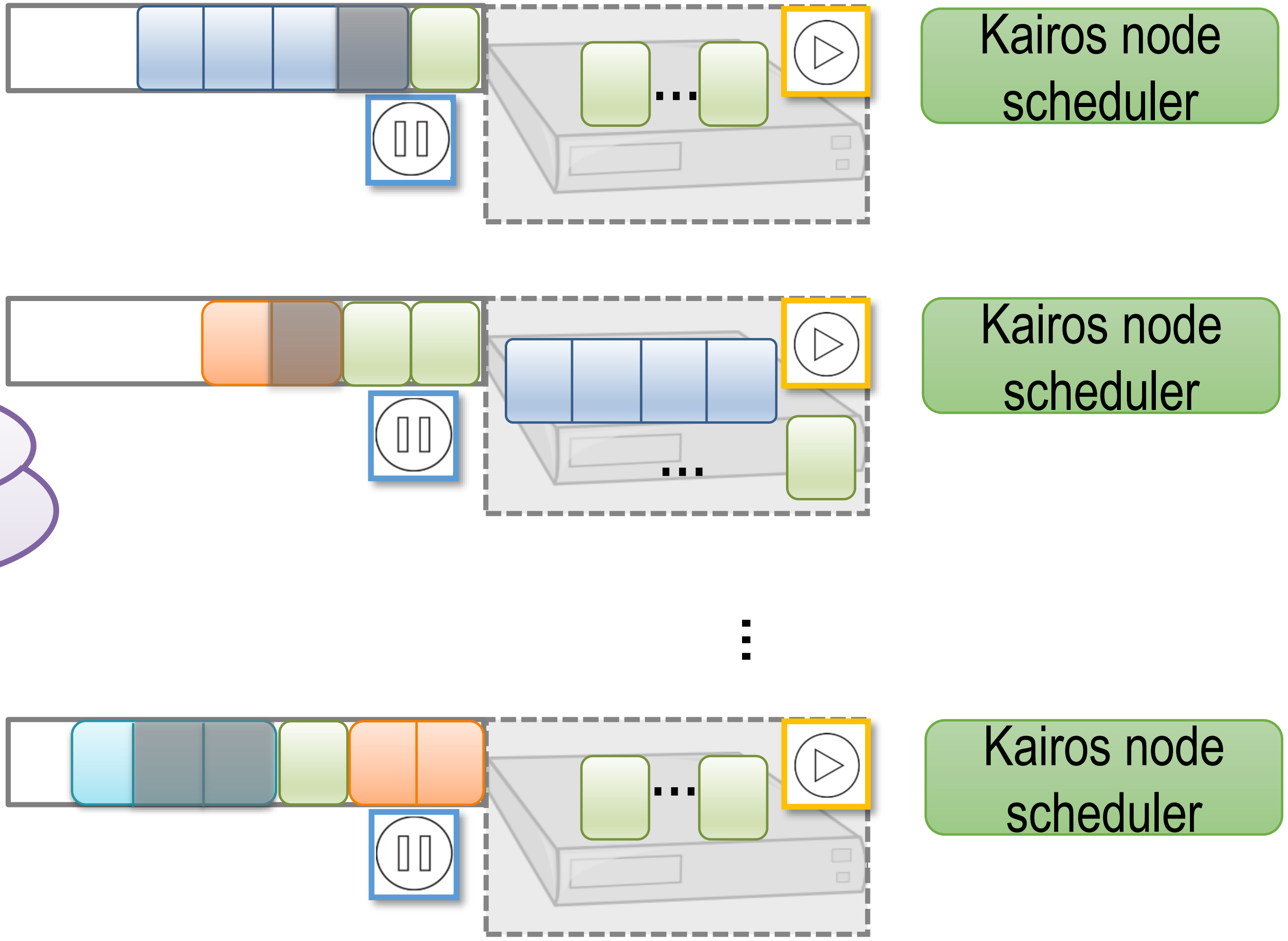
1. Shorter tasks have priority (no head-of-line blocking)
2. Shorter tasks –very likely– execute until completion

**Performance modeling and design of computer systems: queueing theory in action M. Harchol-Balter 2013*

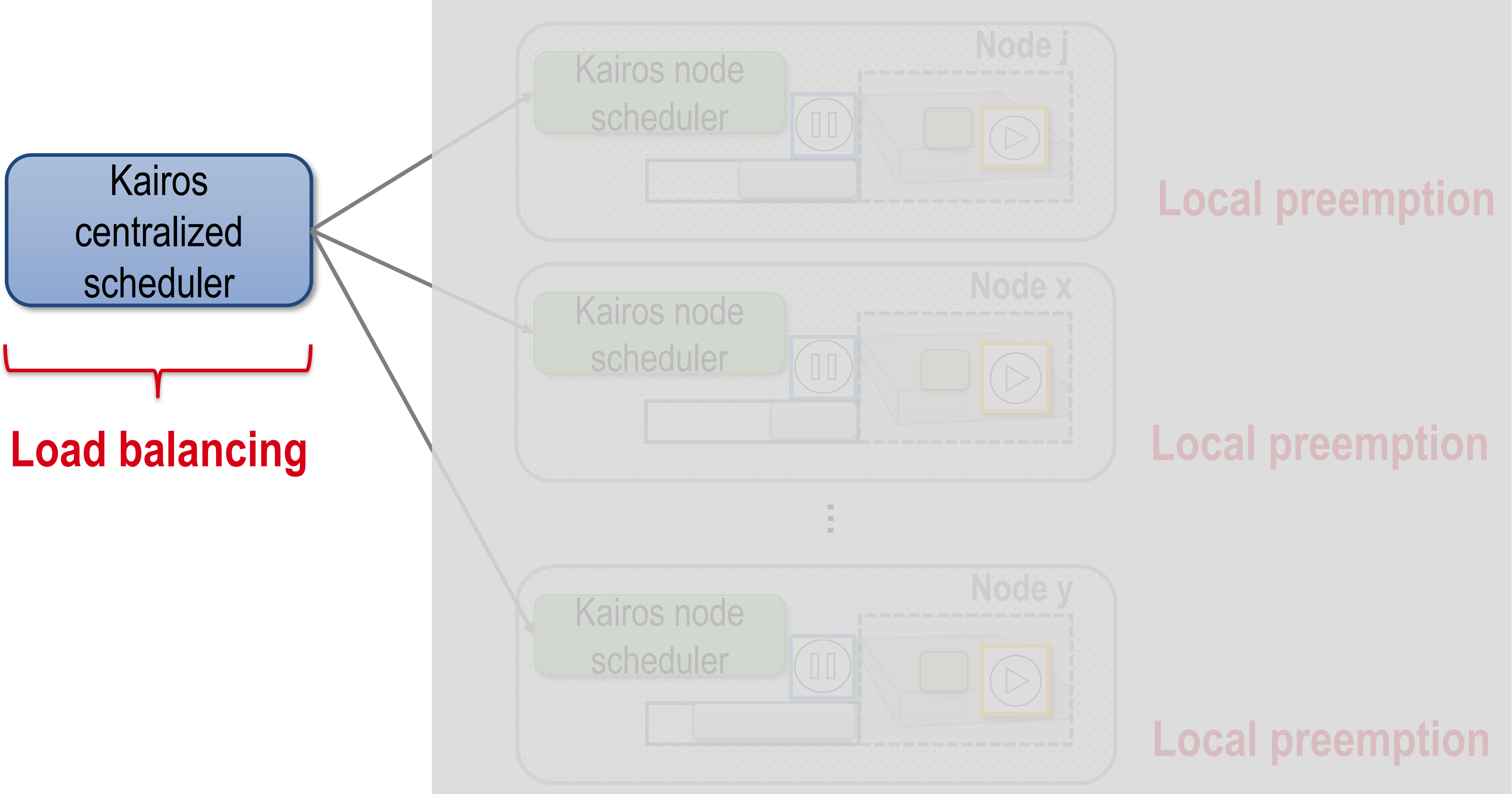
Kairos distributed scheduling

- Node schedulers
  - LAS at the nodes

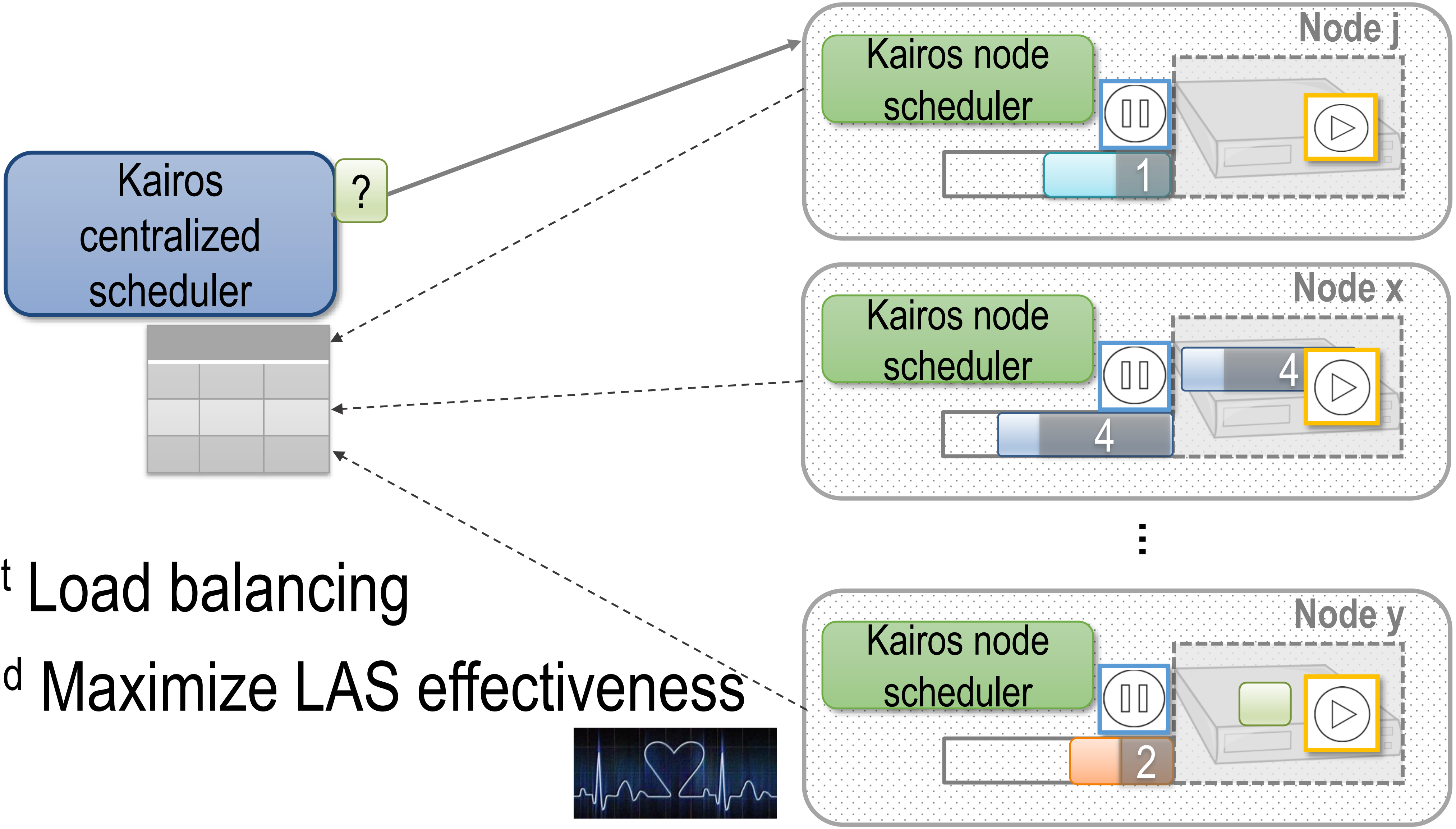
How to dispatch tasks among nodes?



Kairos architecture



Kairos centralized scheduling



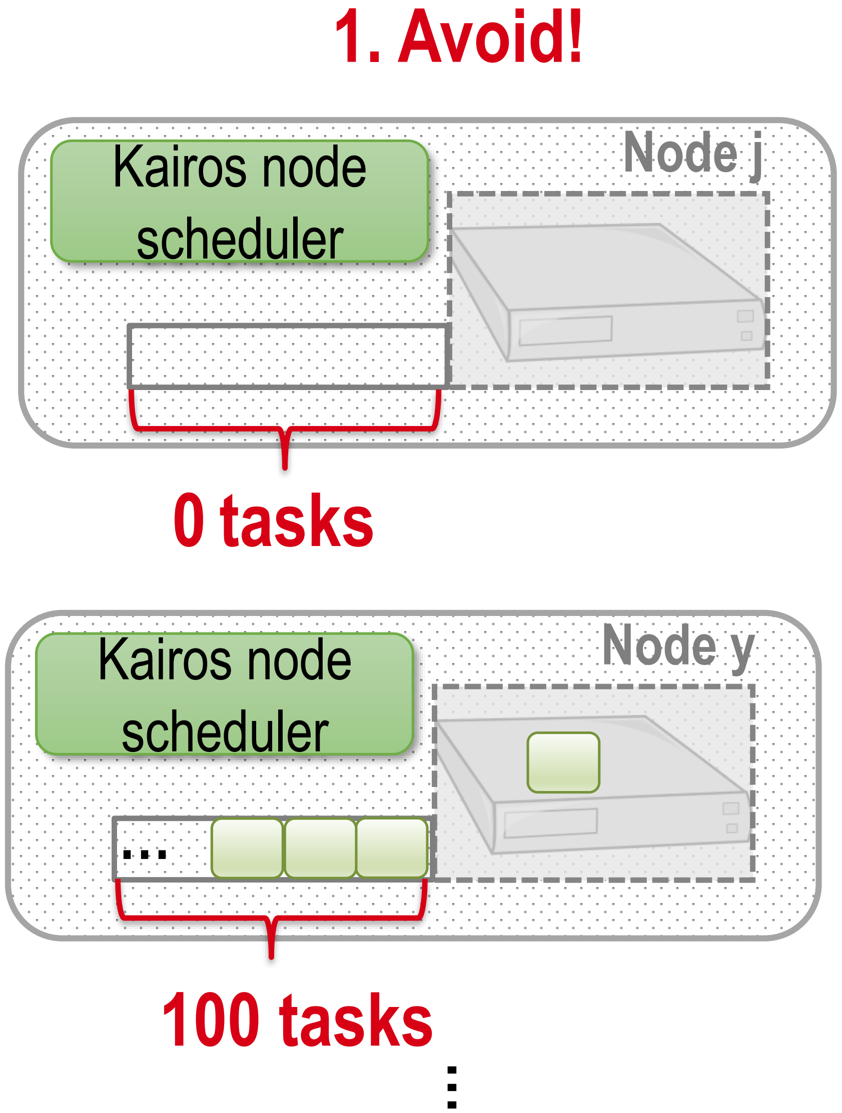
1st Load balancing

2nd Maximize LAS effectiveness

Load balancing rationale

1. Lowest # tasks: no idle nodes

- Bound max # tasks

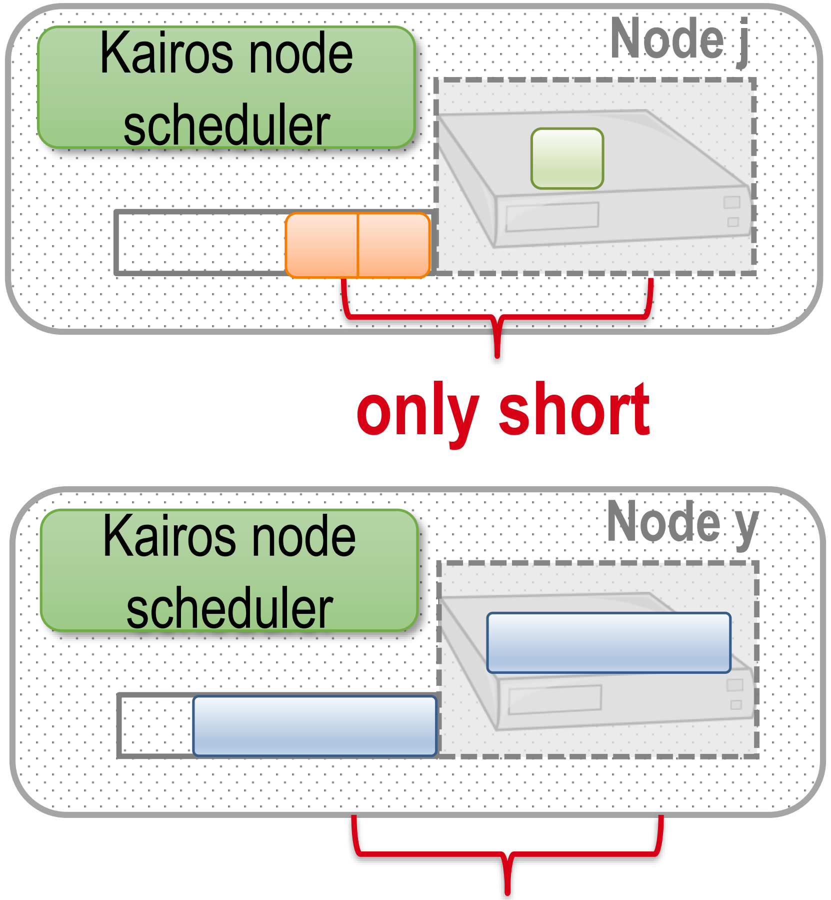


Load balancing rationale

2. LAS-aware policy break ties:

- Heavy-tailed for each node
- Maximize LAS effectiveness
- Node with lowest AS variance*

2. Avoid!



only short

only long

*Minimizing total flow time and total completion time with immediate dispatching. Avrahami et.al. 2003

Multi-layered round robin routing for parallel servers Down et.al. 2006

Kairos recap

1. Distributed:
   - ✓LAS node level
2. Centralized:
   - ✓LAS-aware load balancing technique

Evaluation

- Yarn and Docker containers
- 120 cores in 30 nodes
- heavy-tailed workload (100 jobs)

- Metrics: Job runtime and slowdown
- Compare to: Big-C [ATC'17], FIFO

- Simulation: Google trace, compare to Eagle [SoCC'16]

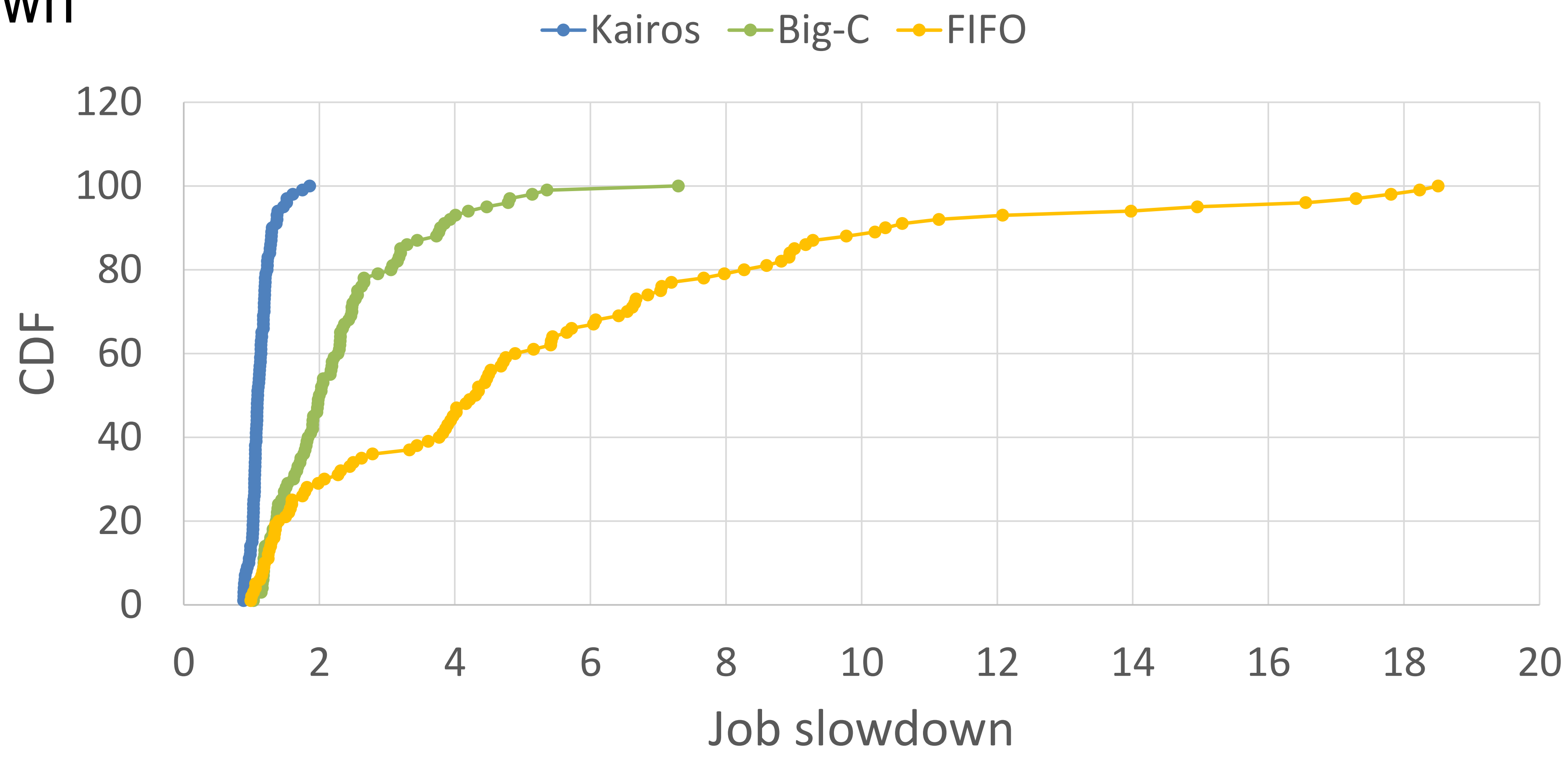
What is the slowdown?

$$job\ slowdown = \frac{observed\ job\ runtime}{uncontended\ job\ runtime}$$

Best job slowdown = 1

Kairos vs Big-C and FIFO

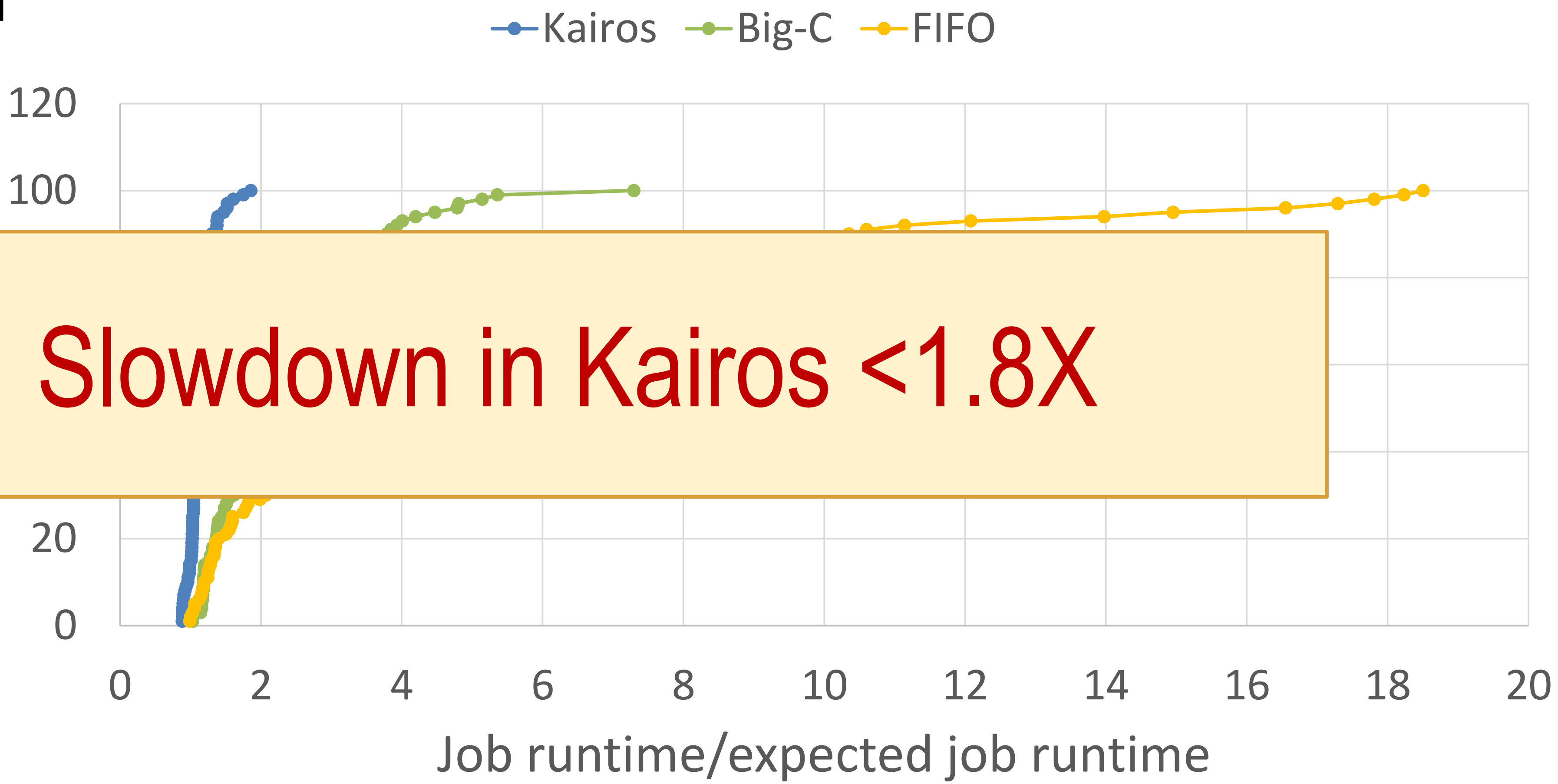
Job slowdown



better ←

Kairos vs Big-C and FIFO

Job slowdown

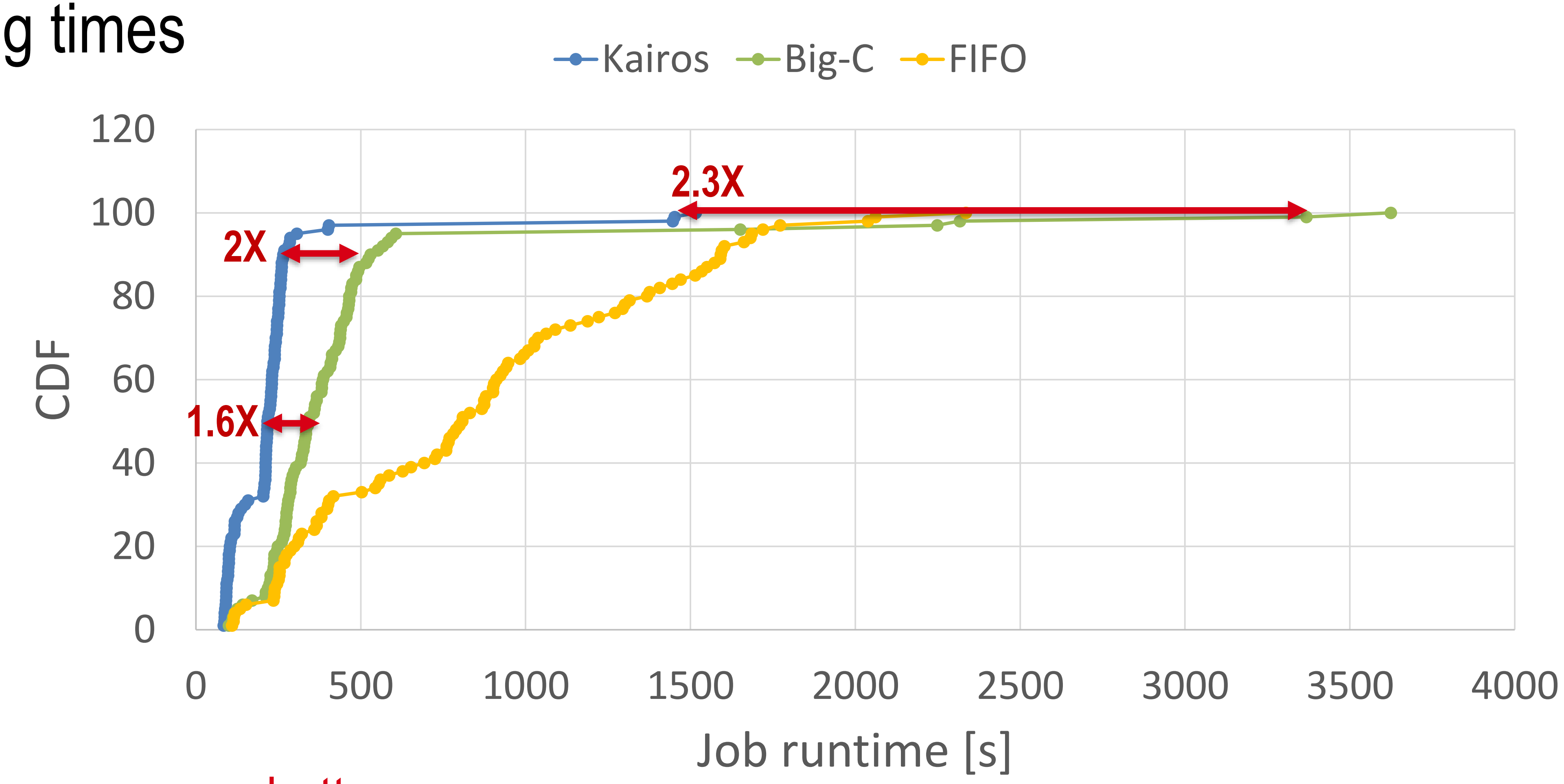


Slowdown in Kairos <1.8X

better ←

Kairos vs Big-C and FIFO

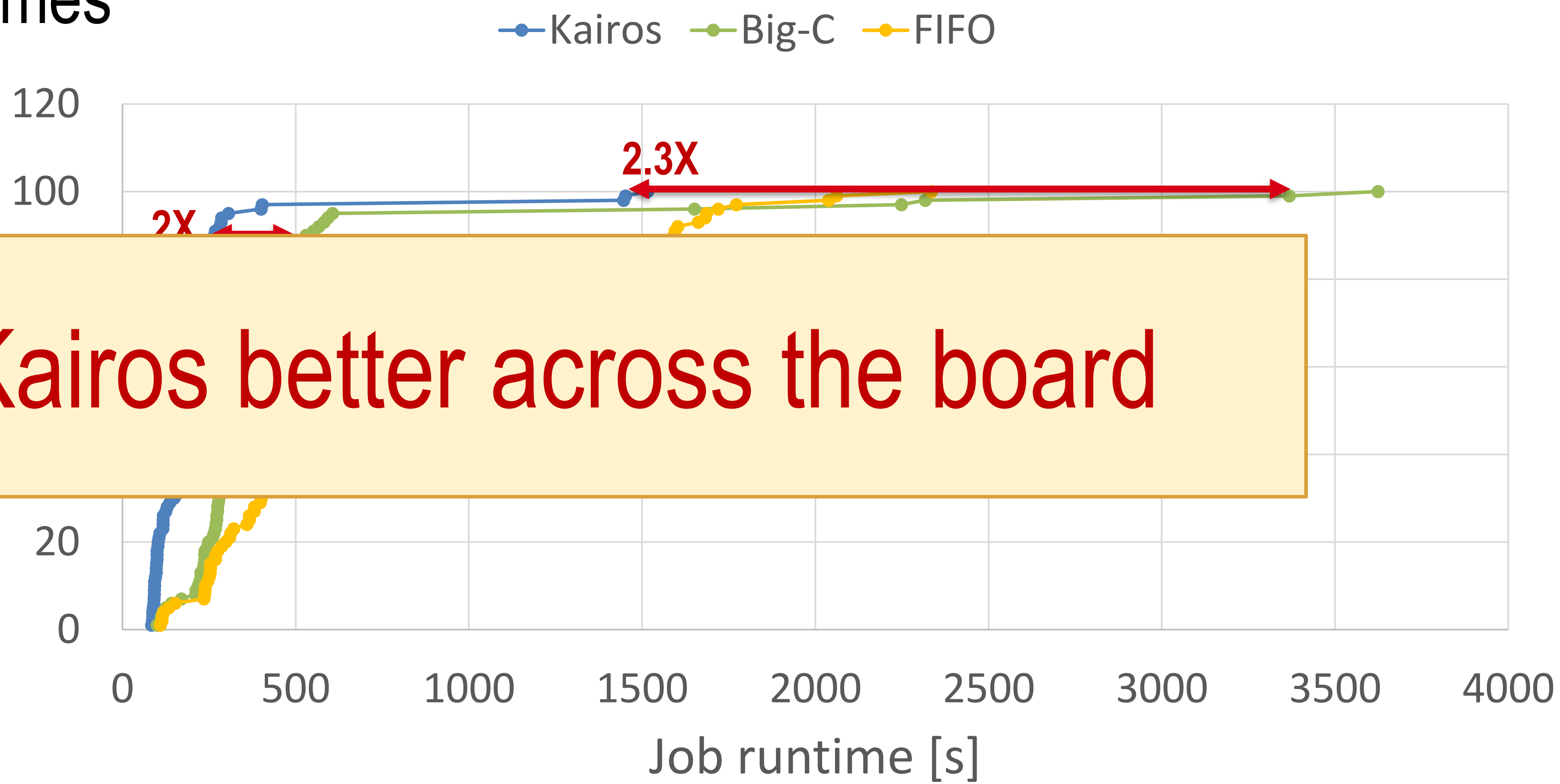
Job running times



better ←

Kairos vs Big-C and FIFO

Job running times

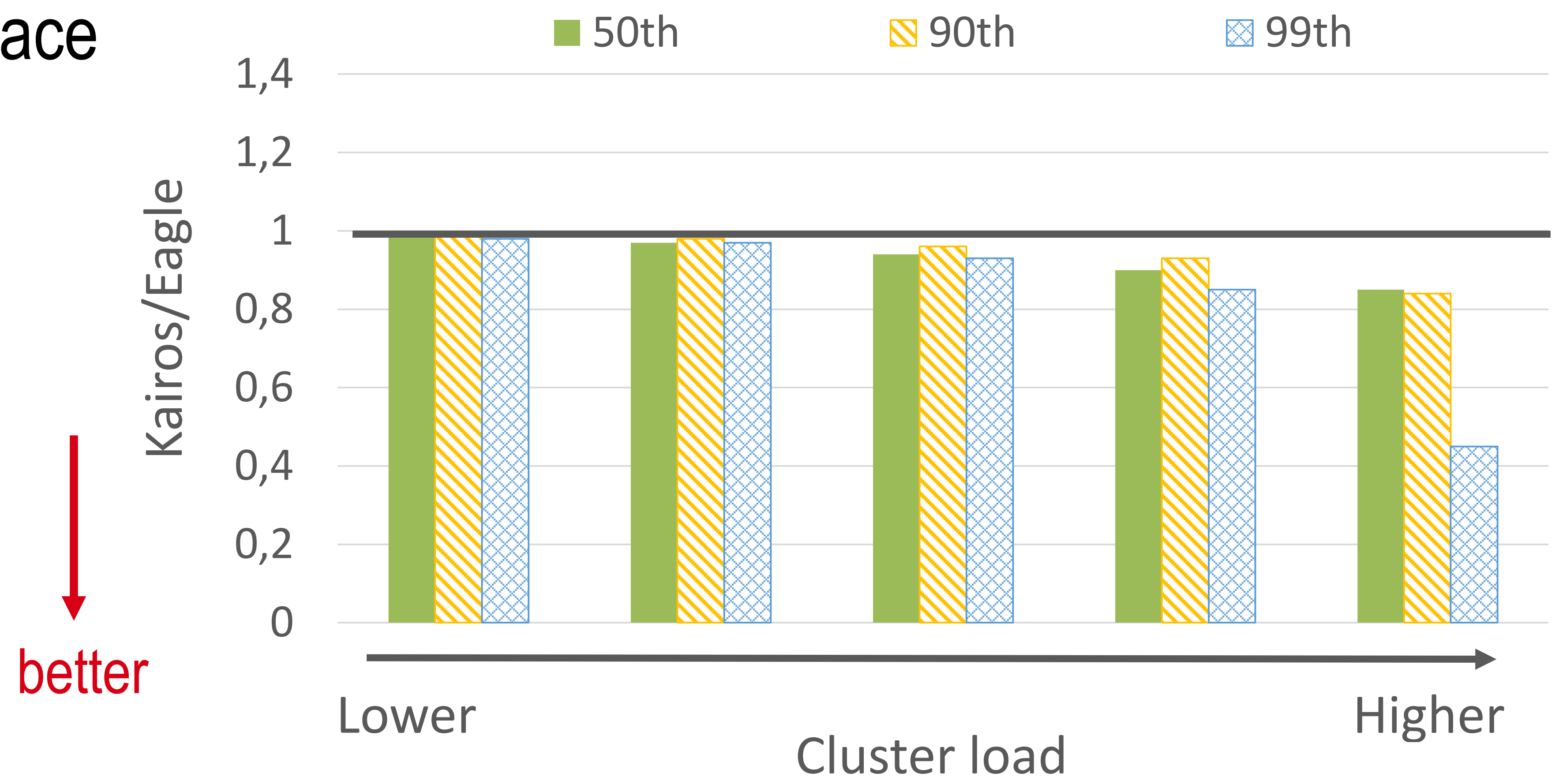


Kairos better across the board

better ←

Kairos vs Eagle

- Short jobs runtime
- Google trace



Kairos vs Eagle

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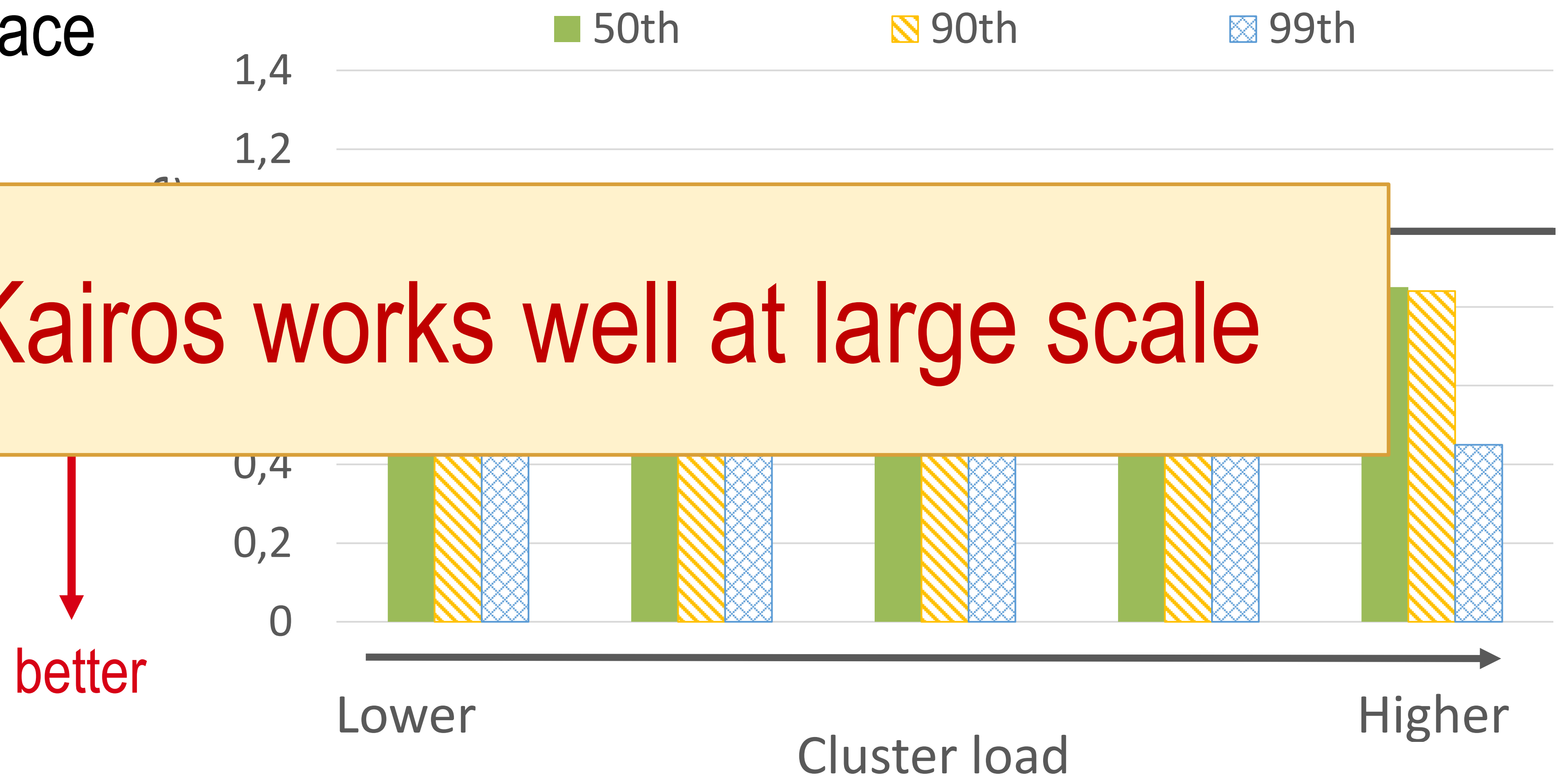

Kairos works well at large scale

Why are we better?

Against FIFO

✓ FIFO does not avoid head-of-line

Against Big-C

✓ We do preemption better

Against Eagle

✓ Preemption

More in the paper

- Evaluation with a uniform workload
- Sensitivity to parameters
- Comparison with other load balancing techniques
- How we do preemption

- Soon open sourced

Kairos

✓First preemptive scheduler without runtime estimates

✓Smart preemption: good job runtime and slowdown

✓LAS at node level
✓LAS-aware load balancing